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KEYPROCESSING PERFORMANCE: A METHOD FOR DETERMINING OPERATOR PE--ETC(U)
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KEYPROCESSING PERFORMANCE: A METHOD FOR DETERMINING OPERATOR PERFORMANCE STANDARDS

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KEYPROCESSING PERFORMANCE: A METHOD FOR DETERMINING OPERATOR PERFORMANCE STANDARDS

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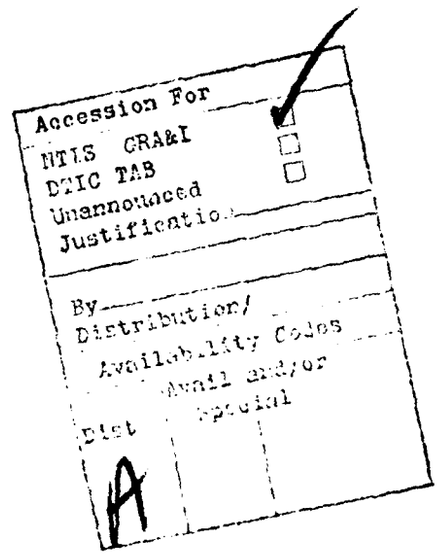
FOREWORD

This research and development was conducted in response to a request by the Naval Sea Systems Command (NSEA 073) and the Long Beach Naval Shipyard (Code 110) to develop a method for developing data entry operator performance standards for users of the Computer Machinery Corporation (CMC) keyprocessing system. This does not imply government endorsement of the CMC or any other keyprocessing system. Rather, the CMC system was used as the basis for development because of its widespread use in keyprocessing operations, particularly those in naval shipyards.

The Navy Personnel Research and Development Center, in an effort to enhance productivity of key entry operators, developed a Performance Contingent Reward System (PCRS) in cooperation with the Long Beach and Mare Island Naval Shipyards. This system, which incorporates the principle of work motivation with work measurement to increase productivity, is described in NPRDC Technical Reports 78-13 and 78-20 and in NPRDC Special Report 78-7. Although the system has resulted in remarkable increases in operator productivity, its more general application requires that performance standards be developed against which individuals can be compared. This report presents a simple method to calculate performance standards for such a system.

This work was significantly improved by the assistance of the management and employees of the Mare Island and Long Beach Naval shipyards; their help is sincerely appreciated. The efforts of Thomas T. Trent of NAVPERSRANDCEN in the early stages of this effort are greatly acknowledged.

DONALD F. PARKER
Commanding Officer



SUMMARY

Problem

Although it has been shown that Performance Contingent Reward Systems (PCRSs) significantly improve individual and group productivity for key entry operators in data processing, their application requires that performance standards be established against which individuals can be compared. For key entry operators, standards must be established in terms of keystrokes per hour and percent of time in production. To date, no simple and quick method exists for setting standards when substantial historical information is not available.

Purpose

The purpose of this research and development was to develop a method for computing standards for the variety of tasks performed by key entry operators in both writing and verification modes.

Approach

Because of the difficulties associated with the traditional methods of setting standards, a new method was devised predicated on the influence of attributes or characteristics of source documents and procedures on keystroke rates of operators using the CMC keyprocessing system. When the characteristics associated with keystroke rates are known, standard keystroke rates can be set for these documents and procedures based on the weight of the different characteristics.

Historical data on keystroke rate for over 160 different tasks were obtained from two shipyard key entry stations using the CMC system, and adjusted to reflect a normal or "fair day's" work pace to be used as the criterion in a multiple regression analysis of the task characteristics. For each task, over 40 different characteristics were analyzed to determine their effect on keystroke rate.

Results

The statistical analysis indicated that only six characteristics were required to set accurate standards for CMC system key punch operators: (1) the size of the document, (2) the color contrast of the document, (3) the maximum number of strokes per source document, (4) the maximum number of strokes per record, (5) the total number of punched fields per record, and (6) the number of records processed per year per operator. These characteristics have a number of defined categories or levels, each of which have assigned keystroke values--either positive or negative--for both writing and verification modes. For example, the size of the document has five levels--reflecting intervals from 3 to 20 inches. The values assigned to these levels, as well as the base rates for writing and verifying document/procedures, were derived by the statistical analysis.

The keystroke standard for a document/procedure is computed by rating it on the six characteristics listed above; that is, by identifying those characteristic levels that apply to the document/procedure and using the values for those levels to adjust the base rate. Keystroke standard rating forms--for both write and verify modes--were developed to facilitate this process.

This method for setting standards also applies to design of source documents and procedures and to workload planning and staffing. Methods also were presented for setting standards on other equipment (e.g., IBM 129) and for machine usage.

Recommendations

The methods described in this report should be used to set standards wherever CMC keyprocessing systems are used in Navy data entry operations.

CONTENTS

LIST OF FIGURES

INTRODUCTION

Problem

The use of computers to perform accounting, administrative, and clerical tasks has increased tremendously in recent years. As a result, the methods used to input data and program codes to computers have become more time consuming and important to the efficient use of organizational resources. In many cases, up to 40 percent of all computer personnel are directly involved in transcribing data and program codes in machine readable form. If key entry employees are to be more productive (using present methods of processing), a system is needed for measuring the volume of work to be done and the time expected to complete it. This process of measuring and subsequently determining management expectations for production is referred to as "setting standards." Meaningful standards are always important, particularly when they are used as the basis for evaluation and reward determination.

To improve employee motivation by linking rewards more closely to performance, the Navy Personnel Research and Development Center has developed a Performance Contingent Reward System (PCRS) that has substantially improved productivity in key entry employees (Shumate, Dockstader, Nebeker, 1978; Dockstader, Nebeker, & Shumate, 1978; Bretton, Dockstader, Nebeker, & Shumate, 1978). Fundamental to the implementation of a PCRS is the development of performance standards against which individuals can be compared as the basis of determining differential rewards.

Purpose

The purpose of this research and development was to develop a method for determining work standards for those using Computer Machinery Corporation (CMC) keyprocessing systems in support of a PCRS. This does not imply government endorsement of the CMC or any other keyprocessing system. Rather, the CMC system was used as the basis for development because of its widespread use in naval shipyards and other keyprocessing activities.

Background and Scope

In the key entry or key punching process, the key entry operator (sometimes called a key puncher or data transcriber) typically manually transcribes written or printed information by keying the information into specially designed transcribing equipment. The information to be entered generally consists of alphanumeric coding prepared on a standardized form called a source document. Source documents are usually processed in bundles called batches that can vary in size from a single document to several hundred. The information on the source document is entered in an ordered and organized manner so it can be read by the computer.

The standardized method of and instructions for entering a source document are referred to as a procedure. Typically, there is a different procedure for each source document. Along with general instructions, the procedure defines the format of each record to result from the key entry. A record is a specified set of information associated with an entity (e.g., an employee or an account), which is used by the computer when processing the information. The format of the record specifies the location of the various pieces of information. These pieces of information are called fields and are made up of columns of either alphabetic, numeric, or special characters that can be read by the

computer. An example of a source document with the format of its records, fields, and columns is provided in Figure 1; and the procedure for entering it, in Figure 2.

Documents can be entered in two modes--write or verify. When a document is originally entered or "punched," it is being written. Because computers are so unforgiving of errors, however, most documents are entered again. The two entries are then compared, column by column, to check for errors that must be corrected. The second entry is called verification and, typically, is done by someone other than the write operator.

In early keypunch machines, the operator pressed keys at a typewriter-like keyboard to make holes in paper cards or tape that could be "seen" by card readers. Today, however, in many installations, these cumbersome physical records (cards) have been replaced by much smaller magnetic disks and tapes containing machine-readable characters comprised of minute electromagnetic marks. Although a number of different types of equipment are available to produce these marks, a popular system and the one of prime concern here is the Computer Machinery Corporation (CMC) keyprocessing system. This system consists of a central control console, which is actually a minicomputer, linked to a number of remotely located keystations. The operator sits at a keystation and keys in the data to be transcribed according to standardized procedures. After the operator keys in a process identification number, which informs the console of the procedure to be used, the console fetches from its memory of several hundred different procedures the appropriate one to be used and records the operator's input of information with the proper structure on disk memory. This stored information is later transferred to the magnetic tape for computer use.

One of the advantages of the CMC system is its capability to provide a number of alternative procedures or formats for entering the same or similar source documents, as well as a series of formats to be followed sequentially for very complex procedures. In some applications, as many as eight alternative formats--called levels--can be specified. If these formats are to be followed sequentially, they are chained together. When a number of levels are associated together, they are referred to as a Multiple Format Group (MFG). When shorter and simpler formats are used, they are called single formats. Even a single format, however, can have an alternate to the main format if necessary. Another advantage of the CMC system is its capability of measuring the work produced with it. For each batch of work that is opened, the system records the identity of the keystation and the operator, the mode used (write or verify), the procedure used, the time of opening, the number of keystrokes entered, the number of records produced, the number of corrections made (if verifying), and the time of closing. This information can then be used to produce a number of valuable statistics, such as the number of keystrokes per hour made by an operator. This work measure is extremely useful for measuring operator and shop performance, because it can be concretely measured and is directly related to operator behavior. In addition to its value in developing performance standards, it can be very useful in measuring productivity and developing interventions to improve that productivity.

WORK WEEK SCHEDULE CHANGES

Forward to Company Time Department, Payroll Section, Code 612, one week prior to effective pay period.

FROM: SHOP

TO: DATA PROCESSING OFFICE (CODE 116)

VIA: COMPTROLLER DEPARTMENT (CODE 61)

IT IS REQUESTED THAT THE ADMINISTRATIVE WORK WEEK OF EMPLOYEES LISTED BE CHANGED CONSECUTIVE DAYS OFF IN WORK WEEKS 1 AND 2 ARE INDICATED NUMERICALLY AS FOLLOWS:

DAY		DAY	
SUN	1	THU	5
MON	2	FRI	6
TUE	3	SAT	7
WED	4		

TRANS CODE	SHOP NO.	PAY NUMBER	EMPLOYEE NAME	DAYS OFF WEEK 1	DAYS OFF WEEK 2	PAY PERIOD
1-3	11-12-13	15-16-17-18-19		24 25	26 27	75 76 77 78 79 80
022						
022						
022						
022						
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CANCELLED DAY Payroll Tech.

Figure 1. Example of a source document.

BATCH NAME: FPI11311 PAGE 1 OF 1

KEY PROCESSING PROCEDURE AND RECORD FORMAT LAYOUT
UNIVAC V77-600/V77-800 (7-76)

630.12

FPI 113/11

TITLE: WORK WEEK SCHEDULE CHANGES

109

SOURCE DOCUMENT: WORK WEEK SCHEDULE CHANGES - ESTES FORM 7410/42 (10-65)

DATE: 19 APR 1976

TRANSACTION CODE(S): "Ø22"

FIELD NO.	COLUMNS	M/O	SKIP/DUP	DESC	VER	LNG	FIELD NAME	REMARKS
								1) SOURCE DOCUMENTS MUST HAVE A PAY... SECT. SIGNATURE ON BOTTOM OF FORM.
								2) IF NOT SIGNED, RETURN TO CODE 630.12 VIA CODE 115.1 (DO NOT KEYPUNCH).
								3) "KEYPUNCHED BY" BLOCK MUST BE FILLED IN BY KEYPUNCH OPERATOR.
								4) "VERIFIED BY" BLOCK MUST BE FILLED IN BY VERIFIER.
1	1-3	M	D	N	V	3	TRANS CODE	"Ø22"
2	4-10		S	A	V	7		
3	11-13	M		N	V	3	SHOP NO.	1) FIELD INCLUDES SHOP PREFIX IN COL. 11
4	14-19	M		Z	V	6	PAY NUMBER	
5	20-63		S	A	V	44		
6	64-65	M		N	V	2	DAYS OFF WEEK 1	
7	66-67	M		N	V	2	DAYS OFF WEEK 2	
8	68-74		S	A	V	7		
9	75-80	M		N	V	6	PAY PERIOD	
10	81-142		S	A	V	62		
11	143-204		S	A	V	62		

OUTPUT FILE ID: FP113Ø
CARD OUTPUT

DISPOSITION: SOURCE DOCUMENTS TO CODE 630.12 VIA 115.1
TAPE TO CODE 115.2.

LEGEND:
M/O: M=MANDATORY, Ø=ZERO FILL FIELD
SKIP/DUP: S=SKIP, D=DUPLICATE
DESC: N=NUMERIC FORMAT, A=ALPHA FORMAT, *N=A/N FIELD (N) FORMAT, *A=A/N FIELD (A) FORMAT, Z=RIGHT JUSTIFY AND ZERO FILL, B=BALANCE FIELD
LNG: LENGTH OF FIELD

Figure 2. Example of procedure for entering source document.

APPROACH

Traditional Methods for Developing Standards

The idea of a performance standard is relatively simple and straight-forward: It is inextricably tied to the notion of "a fair day's work for a fair day's pay." Standard performance is the performance level that can be expected from an average, fully qualified operator, working at a normal pace. Stated in terms of key entry operators, standard performance is the number of keystrokes per hour that should be expected from an operator. When standard performance can be defined, the task of effective management and supervision becomes much simpler.

Standards can be used for performance evaluation, reward determination, workload planning, and staffing requirement determination. In addition, when individuals and groups can be compared against a standard rather than to each other, many of the negative aspects of evaluation are diminished.

Even though setting standards is a simple idea, the actual procedure for doing so often ends up being very difficult and time consuming. For years industrial engineers have attempted to develop practical and accurate methods for developing standards. Alternative methods that have been used traditionally to set standards (cf. Grillo & Berg, 1959) include (1) use of historical records, (2) stop-watch studies, (3) work sampling, (4) micromotion analysis, and (5) use of predetermined time standards. While each of these methods has certain advantages and disadvantages, none has been satisfactorily applied to key entry operations. Since the number of keystroke rates required for different procedures can vary by as much as 350 percent, it is clear that a single standard cannot be used for all procedures. Further, since the mix of work performed by an operator can vary from day to day and from operator to operator, a single standard would be inequitable as a basis for evaluating and rewarding operator performance. This suggests that different standards need to be set for the different procedures. Except for using historical records, however, the traditional methods of setting standards can be very time consuming, especially when some procedures are low in volume or are one-time jobs or when a large number of different procedures are in use. The historical records method is not acceptable when standards are used for evaluation and rewards unless evaluators know the pace of the work and when new source documents or procedures are likely to be added, since operators can artificially influence standards to increase their potential rewards. The application of predetermined time standards or micromotion analysis is not acceptable because the observed keystroke rates vary considerably from the rates typically set by these methods. This may occur because many of the factors contributing to keystroke rate are not steps in the procedure for key entry. For example, since operators are more likely to lose their place on large documents than on smaller ones, the large ones take longer to key enter. Since time differences due to transcribing from several different size documents are not considered in developing a predetermined time method, they would not have an impact on the standard. Thus, it would not be a true measure of the operator's performance.

Probably the most accurate method of setting standards for this type of work is the stop-watch method, in which each procedure is timed and the standards are set based on average times at a normal pace. For all the different procedures used on the CMC system, however, this method would require an unreasonable length of time, particularly since some of the procedures are processed only rarely or have low volume.

Development of New Methods

Because of the difficulties associated with the traditional methods of setting standards, a new method was devised predicated on the effect of attributes or characteristics of source documents and procedures on keystroke rates of operators using the CMC keyprocessing system.[1] When the characteristics that are associated with keystroke rates are known, standard keystroke rates can be set for these documents and procedures based on the weight of the different characteristics. When new documents or procedures are added, these weights can be used to set standards for these jobs. Multiple regression analysis (Bottenberg & Ward, 1963; Christal, 1967) provides a well established statistical technique for finding the weight of measurable characteristics for determining a criterion value. For our purposes, the characteristics to be considered are the measurable attributes of the source document and the procedure used to format and enter it. The criterion value is the keystroke rate as determined from a large number of timings using the batch open-close times on the CMC system as a stop watch.

Historical data on keystroke rate for over 160 different tasks or procedures were obtained from two shipyards with CMC installations. Care was taken to ensure that procedures selected had wide differences in keystroke rates. These data were adjusted to reflect a normal work pace and used as the criterion values in a multiple regression analysis of document or procedure characteristics. For each task, over 40 such characteristics were analyzed to determine their effect on keystroke rate. The characteristics associated with the source document included the size of the document, card vs. paper stock, boxed vs. open fields, characters per square inch, and the color contrast between paper and ink. Those associated with the procedure itself included single vs. multiple format, the number of levels used, the number of fields defined, the maximum possible keystrokes per record, the number of alpha fields, and the log transform of number of records written per operator per year.

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[1]Details of the logical and empirial development of this method will be provided in a separate report.

RESULTS

Characteristics Required in Setting Keystrokes Standard

The results of the multiple regression analysis showed that only six of the 40 characteristics included were required to set accurate standards for CMC key punch operators. These six characteristics are listed in Table 1 and described in the following paragraphs. As shown, each characteristic has a number of defined categories or levels, each of which has assigned keystroke values--either positive or negative--for both writing and verification modes. These values, as well as the base rates for writing and verifying document/procedures--4320 and 6024 respectively--were derived from the statistical analysis.

Size of Document

The size of the document is determined by measuring it from top to bottom, and rounding off results to the nearest inch. As shown in Table 1, this characteristic has five levels, which, grouped together, correspond to the size of observed source documents. The values for these levels negatively influence the keystroke base rate. Longer documents have a slower entry rate; thus, the longer the document, the more negative the influence.

Color Contrast of Document

The color contrast of a source document is determined by the contrast between the print and the paper. This characteristic has only two levels: (1) black print on white paper and (2) any other print/paper combination that has been observed. This characteristic also has a negative influence on the keystroke base rates, with the black and white combination having a more negative effect than the other observed combinations.

Maximum Number of Records per Document

This characteristic refers to the maximum number of records that can be listed on a source document, which is determined by counting the spaces for separate entries on the document. It has five levels, which have a positive influence on the base rates. The higher the number of records, the more positive the effect.

Maximum Number of Strokes per Record

For each record of a procedure, there are a maximum number of strokes that can be written. This number can be determined by referring to procedure instructions (e.g., Figure 2) and counting the strokes to be written in the column labeled "LNG" (length), excluding strokes indicated as skipped (S) or duplicated (D). It is important to note, however, that only the first level of a Multiple Format Group (MFG) process and the main program of a single format are considered in making this determination.

This characteristic has five levels, which positively influence the base rates. The higher the number of strokes, the more positive the effect.

Total Number of Punched Fields per Record

The total number of punched fields per record is determined by referring to the procedure instructions (e.g., Figure 2) and counting the fields listed under the "Field

Table 1

Document/Procedure Characteristics Required
in Setting Keystroke Standard

Characteristic	Category/Level	Keystroke Value: Writing Mode	Keystroke Value: Verification Mode
Base Rate		4320	6024
Size of document (Measured in inches --top to bottom)	3 and 4	-687	-629
	5 through 8	-1206	-1104
	9 through 12	-1710	-1565
	13 through 16	-2214	-2026
	17 through 20	-2733	-2501
Color contrast of document (print/ paper)	Black/white	-1133	-1107
	Other combinations: Black/Green Black/Yellow Black/Blue Green/White Black/Manila	-567	-553
Maximum number of records per document	1 through 21	189	244
	22 through 40	532	688
	41 through 60	875	1132
	61 through 79	1218	1575
	80 through 99	1561	2019
Maximum number of strokes per record	8 through 54	902	726
	55 through 101	2244	1805
	102 through 147	3585	2884
	148 through 194	4927	3963
	195 through 240	6269	5043
Total number of punched fields per record	1 through 12	-452	-273
	13 through 24	-1222	-738
	25 through 35	-1991	-1202
	36 through 47	-2760	-1667
	48 through 58	-3530	-2132
Number of records written per operator per year	3.09 through 13.49	1079	1114
	13.50 through 58.49	1937	2001
	58.50 through 257.25	2796	2887
	257.26 through 1118.75	3654	3774
	1118.76 through 4865.75	4501	4648
	4865.76 through 21162.75	5354	5529
	21162.76 through Highest	6206	6409

Name" column, excluding those indicated as skipped or duplicated. As above, only the first level of an MFG or the main program of a single format is considered. As shown in Table 1, this characteristic has five levels, which have a negative impact on the base rates. The higher the number of punched fields, the more negative the effect.

Number of Records Written per Operator per Year

This characteristic is determined by assessing the total number of records that are or will be processed (written) during 1 year and dividing that number by the number of full-time equivalent operators for that year. It has seven levels, which positively influence the base rates. The higher the number, the more positive the effect.

Computing the Keystroke Standard

The keystroke standard for a document/procedure is computed by rating it on the six characteristics listed above. This is done by identifying those characteristic levels that apply to the document/procedure and using the values for those levels to adjust the base rate. Keystroke standard rating forms--for both write and verify modes--that have been developed to facilitate this procedure are provided in the appendix. Examples of completed rating forms--for the document/procedure ilustrated in Figures 1 and 2--are provided in Figures 3 and 4. The steps required to complete the form for the writing mode are described below:

1. Since the actual document (Figure 1) is 11 inches long, it falls within the third level listed (9 through 12 inches). Thus 1710 keystrokes are subtracted from the base keystroke rate of 4320.

2. Since the actual document is printed with black ink on manila paper, it falls within the "other combinations" level. Thus, 567 keystrokes are subtracted from the base rate.

3. There are 19 spaces for separate entries on the sample document, thus placing it in the first level (1 through 21). This means that 189 keystrokes are added to the base rate.

4. Turning to the procedure for entering the document (Figure 2), we find that there are 22 writing strokes, thus placing the document within the first level for this characteristic. The value for this level is 902, which is added to the base rate.

5. The "field" column on the procedure shows that there are six punched fields in the source documents. Thus, it falls within the first level (1 through 12), and 452 keystrokes are subtracted from the base level.

6. Finally, historical records indicated that approximately 1006 records are written a year and that 25 full-time operators are employed. This is equal to 40.24 records per operator per year, which adds 1937 keystrokes to the base rate.

As shown in Figure 3, the keystroke standard for writing the sample document/procedure is 4619. The same procedure listed above, using different amounts for the level values and the base rate, is used to compute the keystroke standard for verifying the sample document/procedure.

It should be noted that the keystroke rates derived from this method of determining standards assume that all the important variability in source document and procedure

KEYSTROKE STANDARD RATING FORM (WRITE)

Source document Work Unit Study Procedure and Format # [illegible] Date [illegible]

Completed by [illegible]

Characteristic	Category/Level	Value (Keystrokes)	Computation
Base Rate			+ 4320
Size of document (measured in inches--top to bottom)	3 and 4	-687	
	5 through 8	-1206	
	9 through 12	-1710	
	13 through 16	-2214	
	17 through 20	-2733	- 1710
Color contrast of document (print/paper)	Black/White	-1133	
	Other Combinations Black/Green Black/Yellow Black/Blue Green/White Black/Manila	-567	- 567
Maximum number records per document	1 through 21	189	
	22 through 40	532	
	41 through 60	875	
	61 through 79	1218	
	80 through 99	1561	+ 189
Maximum number of strokes per record	8 through 54	902	
	55 through 101	2244	
	102 through 147	3585	
	148 through 194	4927	
	195 through 240	6269	+ 902
Total number punched fields per record	1 through 12	-452	
	13 through 24	-1222	
	25 through 35	-1991	
	36 through 47	-2760	
	48 through 58	-3530	- 452
Number of records written per operator, per year	3.09 through 13.49	1079	
	13.50 through 58.49	1937	
	58.50 through 257.25	2796	
	257.26 through 1118.75	3654	
	1118.76 through 4865.75	4501	
	4865.76 through 21162.75	5354	
	21162.76 through 94845.07	6206	+ 1937
TOTAL			4619

Figure 3. Example of completed Keystroke Standard Rating Form (Write).

KEYSTROKE STANDARD RATING FORM (VERIFY)

Source Document Work Unit Sheet, Procedure and Format # PJT 113/11, 167 Date 11/26/78

Completed by Mary Higgins

Characteristic	Category/Level	Value (Keystrokes)	Computation
Base Rate			+ 6024
Size of document (measured in inches top to bottom)	3 and 4	-629	
	5 through 8	-1104	
	(9 through 12)	-1565	
	13 through 16	-2026	
	17 through 20	-2501	- 1565
Color contrast of document (print/paper)	Black/White	-1107	
	(Other Combinations	-553	
	Black/Green		
	Black/Yellow		
	Black/Blue		
	Green/White		
	Black/Manila		- 553
Maximum number records per document	(1 through 21)	244	
	22 through 40	688	
	41 through 60	1132	
	61 through 79	1575	
	80 through 99	2019	+ 244
Maximum number of strokes per record	(8 through 54)	726	
	55 through 101	1805	
	102 through 147	2884	
	148 through 194	3963	
	195 through 240	5043	+ 726
Total number punched fiels per record	(1 through 12)	-273	
	13 through 24	-738	
	25 through 35	-1202	
	36 through 47	-1667	
	48 through 58	-2132	- 273
Number of recrods written per oeprator, per year	3.09 through 13.49	1114	
	(3.50 through 58.49)	2001	
	58.50 through 257.25	2887	
	257.26 through 1118.75	3774	
	1118.76 through 4865.75	4648	
	48.65.76 through 21162.75	5529	
	21162.76 through 94845.07	6409	+ 2001
TOTAL			6604

Figure 4. Example of completed Keystroke Standard Rating Form (Verify).

characteristics were observed in the sample. If new procedures with substantially different characteristics are added or are practiced at other installations, the method's validity may be affected. In such cases, the standards derived from the rating form should be scored as closely as possible to the intervals provided. The computed standard then should be compared to either historical data or trial data to see if the standard appears reasonable, and adjusted if warranted. The method for making adjustments is described on page 13.

It is also important to note that the size of the characters being transcribed in this sample were essentially the same for all documents (approximately 1/8 to 1/4 inch). Any large deviation from this size may have some effect on the keystroke rate. Since most source documents are filled out by hand or typed, however, this is unlikely.

Additional Uses of Standards

As mentioned previously, standards such as these can be used for purposes other than determining standard performance levels. Two additional uses that are particularly valuable are (1) design of source documents and procedures and (2) workload planning. Since keystroke rates can be associated with different documents and procedures, a new source document and its associated procedure can be designed for maximum keystroke rate. For example, if given a choice between a black on white source document or one of the other combinations, the latter should be chosen since it will speed up the writing by approximately 567 keystrokes per hour. It should be pointed out, however, that generally all six characteristics for determining keystroke rate should be considered before selecting the final design. For example, it would be inappropriate to design a document based on the maximum number of keystrokes per record without also determining the number of fields to be used, records per document, and so on. When all these characteristics have been selected, the proposed document/procedure can be evaluated on its record per hour rate as well as its keystroke rate.

In workload planning, these standards can be used to estimate the actual machine hours that will be required to process the planned volume of a specific document/procedure. When this time is known and adjustments are made for nonproductive time (e.g., set-up, clean-up, personal time, unavoidable delay, leave, and other nonmeasured work requirements), the number of man-hours required to complete the work can be estimated. For example, suppose a new job, which was estimated to require the writing and verifying of 500,000 records per year with an average of 35 keystrokes per record, were to be added in key entry without the loss of any existing work. If the standards for this job were determined to be 7250 and 8500 keystrokes per hour for writing and verifying respectively, and if the time to be spent on the work (after adjustments for breaks, leave, etc.) was .70 of paid hours, the number of required persons to complete the job per year could be computed as follows:

1. Total keystrokes to be written--35 x 500,000 = 17,500,000.

2. Keystrokes per paid hour writing this job--7250 x .70 = 5075.00.

3. Payroll hours required to complete the writing of this job each year--17,500,000 ÷ 5075 = 3448.27.

4. Total keystrokes to be verified--35 x 500,000 = 17,500,000.

5. Keystrokes per paid hour verifying this job--8500 x .70 = 5950.

6. Payroll hours required to complete the verifying of this job each year--17,500,000 ÷ 5950 = 2941.17.

7. Total number of hours required to complete this job each year--3448.27 + 2941.17 = 6389.44.

8. Number of full-time persons required--6389.44 ÷ 2080 = 3.07.

Obviously, unless the key entry section already had a surplus of three people, at least three additional people or 6389.44 hours of overtime or contract work would be required to complete the job. Such information would be of value to most managers and supervisors.

Auditing Standards

Standards that are developed with this method for document/procedures already in use should be audited against historical records before they are implemented; that is, they should be compared with historical keystroke rates. By dividing the average keystroke rate for each document/procedure by its calculated standard, the procedure's efficiency is calculated. The average of these ratios is a good index of the work pace or efficiency of the shop. Examining the specific rates of efficiency for all of the document/procedures that make up the average will naturally reveal variability: Some will probably be above standard and some below. Fluctuations between these ratios should not be cause for alarm, since the job histories can be affected by a number of factors that should not influence the standards. For example, if a specific job is done only rarely and then by just a few extremely efficient individuals, the standard may appear to be too low. Likewise, if the history of a specific job is based on a new operator, the standard may appear to be too high. These fluctuations are most likely to occur when the job volume is extremely low; that is, when the specific person or persons doing the job do not represent an average operator working at a normal pace. In such cases, the calculated standard should be used as computed. Occasionally, however, document/procedures may have had a large enough volume to qualify them as being representative of the group, but yet, for some unknown reason, the job efficiency is much less (60% or more) than the average work pace or average job efficiency. Such cases may result from some unusual characteristics of the document/procedure that were not part of the standard setting method. When this appears to be the case, the standard should be set by the following formula: standard for specific document/procedure = historical keystroke rate ÷ average efficiency for the shop.

Once standards have been set and are being used as the basis of evaluation or reward, they should not be increased except in very special circumstances. Since such increases would be likely to result in destroying trust between operators and management and leading to an ineffective PCRS system, any benefits they might provide would be lost. The most likely circumstances that would justify changing standards would be instances when one or more of the six characteristics used to determine standards was changed appreciably. In addition, if any major changes were made in the equipment, it would require an audit of the standards to see if they made a difference in keystroke rate at a normal pace. A normal pace, however, should not be confused with an incentive pace that typically would be observed with a PCRS in effect. Therefore, careful consideration should be given to determining whether or not equipment changes should change standards. Finally, standards might be changed if there is a consensus among the operators that some of the standards are unfair. In such cases, if the feelings are quite strong, it is probably better to adjust the standards rather than to destroy operator management trust and the likelihood of a successful PCRS program. This is particularly

true when the percentage of savings from above standard performance shared with the operators is less than 50 percent of the costs of production.

Other Key Entry Equipment

Most installations having CMC keyprocessing systems use them to process the bulk of the work. Other equipment, however, is frequently used to process small amounts of work that may not be suited to a CMC application. In such cases, this work should be measured, as well as that processed on the CMC, and standards established based on historical averages that have been adjusted for the pace of the workers. That is, if the workers are operating at 110 percent of a normal pace during the periods being timed, the historical rate should be divided by 1.10. This will lower the expected keystroke rate approximately 10 percent to a normal pace.

For equipment like the IBM 129, 029, or 059 key punch machines, standards can be set by estimating the pace from standards developed for the CMC. For example, each procedure done on an IBM 129 can be rated using average rates and the standards developed for the CMC using the following formula:

$$\text{IBM 129 Standard} = \frac{\text{IBM Rate}}{\text{CMC Efficiency}}$$

where:

IBM rate = Average keystroke rate for this procedure done on the IBM 129,

and

CMC *Efficiency* = Average efficiency of CMC procedures completed by those individuals doing the bulk of the IBM work. If all individuals share in IBM work, the shop average can be used.

CMC efficiency is computed as average keystrokes per hour divided by average standard keystrokes per hour. Note that CMC efficiency is entered in the equation as a ratio, not as a percent.

While this method will be sufficient for most work done on other equipment that has an established history, new jobs may be added for processing for which no history exists. When this occurs, the standard for such a procedure can be established by adjusting the computed CMC standard for the procedure to reflect the differences in the other equipment. Using the IBM 129 as an example, the adjustment is made with the following formula:

$$\text{IBM 129 standard} = \frac{CYA}{XB}$$

where:

C = Standard computed for the IBM 129 procedure as if it were being done on the CMC.

Y = Average keystroke rate on all other IBM 129 procedures.

A = Average standard for all CMC procedures.

X = Average standard on all other IBM 129 procedures, computed as if they were on the CMC.

B = Average keystroke rate on the CMC for all procedures.

For example: If C = 7200, Y = 5000, A = 9500, X = 7000, and B = 9750, then

IBM standard = (7200 x 5000 x 9500) ÷ (7000 x 9750)

IBM standard = 5010.99.

It should be pointed out that, in all cases, the averages in the above formula are calculated by weighting each procedure by its relative proportion of the total work.

Time on Machine Standards

For the CMC equipment described earlier, keystroke per hour represents a major determinant of productivity. Since the hours used in arriving at this rate, however, are those logged on the machine and an individual can control, to a large extent, their own hours logged on, standards must be established for the amount of time expected to be logged on as well as keystroke rates. Without this time accountability, it would be difficult to have an effective PCRS because individuals could increase keystroke rate but decrease time in production, allowing them to earn an incentive with no real change in actual output. Once the time-on-machine standards have been established, the rewards can be based on actual productivity as a function of both rate and time at that rate.

The time-on-machine standards are based on the recognition that, in an 8-hour work day, it is impossible to be logged on the machine for the full 8 hours. Allowances for time legitimately spent in such activities as set-up, clean-up, and personal time must be made. A method for determining the amount of that allowance is presented below:

1. Determine the total minutes in a regular workday. Typically, this will be 8 x 60 or 480 minutes.

2. A standard 15 percent allowance is made for personal time, recovery from fatigue, and unavoidable delays. Typically, this will be .15 x 480 = 72 minutes.

3. Compute the times typically devoted by each operator to the following each day:

Activity	A. Frequency	B. Minutes Allowed	C. Total Time Allowed A x B
Setting up, opening, closing and bundling each batch (Time allowance when supervisor services each operator = .66 minutes while self-servicing = 1.00)	16.00	0.66	10.56
System saves	1.00	20.00	20.00
Paid lunch break	1.00	15.00	15.00
Other scheduled non-productive time (e.g., shift overlap)	0.00	0.00	0.00
GRAND TOTAL			45.56

4. Expected productive time is computed as follows:
480 - (72 + 45.56) = 362.44 (1 - (2 + 3)).

5. This expected productive time is then converted to a proportion of the regular work day so it can be used in calculating rewards. Proportion of key entry time expected to be logged on machine = 362.44 ÷ 480 = .755 (4 ÷ 1).

This method is based on a stop-watch study of the CMC process and generally accepted allowances for personal time, recovery from fatigue, and unavoidable delays (Grillo & Berg, 1959). For those items where time values have not been provided for items, they will have to be determined by the individual installation. The time on machine standard at an installation where each operator typically opens and closes 16 batches a day while being serviced by a supervisor would be 397.44 minutes per 8 hours or 83 percent of assigned key entry time. These calculations are for the percent of time that a key entry operator is logged on the CMC when at work and assigned work to do on the CMC. Thus, if they are to be used in total shop workload planning, an additional allowance should be made for leave rates and time on non-key-entry tasks. An operator's efficiency in using the assigned time is calculated by the following formula:

$$\text{Production time} = \frac{T}{SF}$$

where:

T = the time actually logged on the CMC,
S = the calculated percent of time expected to be on the CMC, and
F = the time assigned to be on the CMC.

CONCLUSIONS AND RECOMMENDATIONS

This report was prepared to provide the basic information necessary to understand, compute, and use methods to establish keystroke standards for installations using CMC keyprocessing systems. It is especially appropriate where the standards will be used as part of an evaluation and rewards system such as a Performance Contingent Reward System (PCRS). When properly applied and maintained, it establishes an easy and convenient method of setting keystroke standards that, when used as a part of PCRS, can lead to substantial improvements in productivity and cost reductions. As such, it should be used to set standards whenever possible.

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APPENDIX

KEYSTROKE STANDARD RATING FORMS

KEYSTROKE STANDARD RATING FORM (WRITE)

Source document _____ Procedure and Format # _____ Date _____

Completed by _____

Characteristic	Category/Level	Value (Keystrokes)	Computation
Base Rate			+ 4320
Size of document (measured in inches--top to bottom)	3 and 4	-687	
	5 through 8	-1206	
	9 through 12	-1710	
	13 through 16	-2214	
	17 through 20	-2733	- _____
Color contrast of document (print/paper)	Black/White	-1133	
	Other Combinations	-567	
	Black/Green Black/Yellow Black/Blue Green/White Black/Manila		- _____
Maximum number records per document	1 through 21	189	
	22 through 40	532	
	41 through 60	875	
	61 through 79	1218	
	80 through 99	1561	+ _____
Maximum number strokes per record	8 through 54	902	
	55 through 101	2284	
	102 through 147	3585	
	148 through 194	4927	
	197 through 240	6269	+ _____
Total number punched fields per record	1 through 12	-452	
	13 through 24	-1222	
	25 through 35	-1991	
	36 through 47	-2760	
	48 through 58	-3530	- _____
Number of records written per operator, per year	3.09 through 13.49	1079	
	13.50 through 58.49	1937	
	58.50 through 257.25	2796	
	257.26 through 1118.75	3654	
	1118.76 through 4865.75	4501	
	4865.76 through 21162.75	5354	
	21162.76 through 94845.07	6206	+ _____
TOTAL			_____

KEYSTROKE STANDARD RATING FORM (VERIFY)

Source document _____ Procedure and Format # _____ Date _____

Completed by _____

Characteristic	Category/Level	Value (Keystrokes)	Computation
Base Rate			+ 6024
Size of document measured in inches--top to bottom)	3 and 4	-629	
	5 through 8	-1104	
	9 through 12	-1565	
	13 through 16	-2026	
	17 through 20	-2501	- _____
Color contrast of document (print/paper)	Black/White	-1107	
	Other Combinations	-553	
	Black/Green Black/Yellow Black/Blue Green/White Black/Manila		- _____
Maximum number records per document	1 through 21	244	
	22 through 40	688	
	41 through 60	1132	
	61 through 79	1575	
	80 through 99	2019	+ _____
Maximum number of strokes per record	8 through 54	726	
	55 through 101	1805	
	102 through 147	2884	
	148 through 194	3963	
	195 through 240	5043	+ _____
Total number punched fields per record	1 through 12	-273	
	13 through 24	-738	
	25 through 35	-1202	
	36 through 47	-1667	
	48 through 58	-2132	- _____
Number of records written per operator, per year	3.09 through 13.49	1114	
	13.50 through 58.49	2001	
	58.50 through 257.25	2887	
	257.26 through 1118.75	3774	
	1118.76 through 4865.75	4648	
	4865. 76 through 21162.75	5529	
	21162.76 through 94845.07	6409	+ _____
TOTAL			_____

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